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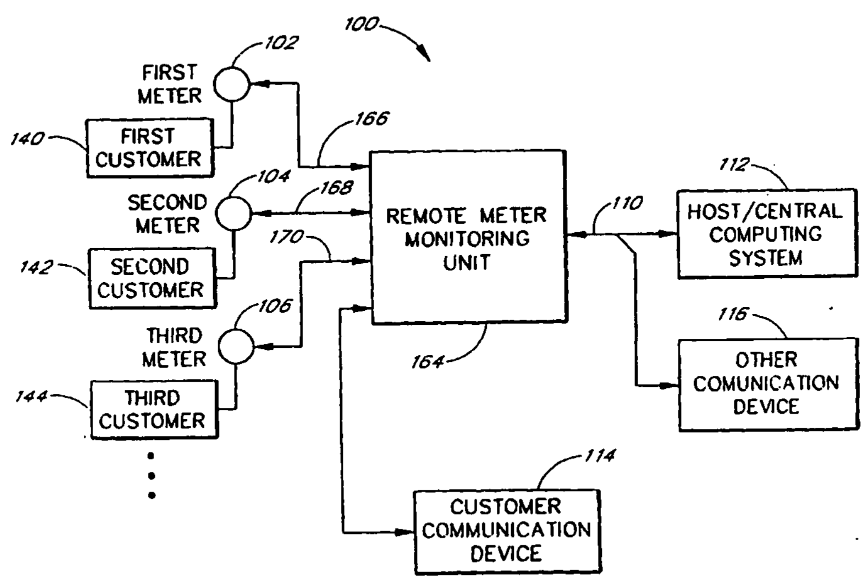

(57) Abstract: A remote monitoring unit as shown in the figure is coupled to an electronic meter (140, 142, 144). The remote monitoring unit communicates with a central computer (112) via a communication network (110, 152). The remote monitoring unit is configured to detect a noise signal or footprint generated by the electronic meter when the meter is functioning properly and the meter is properly coupled to the remote monitoring unit. If the remote monitoring unit detects a change in the noise signal, the remote monitoring unit sends a signal to the central computer. The signal may notify the central computer that the meter has lost power, restored power, malfunctioned, or has been disconnected from the remote monitoring unit.

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REMOTE METER MONITORING SYSTEM AND METHOD

Background of the Invention

Field of the Invention

The present invention relates to a remote monitoring system. Specifically, the present invention relates to a remote meter monitoring system and methods of use thereof.

Description of the Related Art

Utility companies, such as electric, water, and gas companies, currently send field personnel to read utility meters associated with residential, industrial or commercial buildings. Field personnel record the meter readings, and other company personnel compile and organize this data.

For service disruptions, it may be difficult for utility companies to detect and isolate the source of the disruption. It may be difficult to distinguish a disruption in the service from a malfunction in the meter. It may also take considerable time to restore service to the customers.

A 'mechanical' utility meter typically does not use a power supply. In contrast, an 'electronic' or solid-state utility meter often has a power supply and a microcontroller. Electronic or solid-state meters are often designed to be low-powered devices, i.e., the electronic meters are designed to consume small amounts of power. Some electronic meters have an active mode and an idle mode. In idle mode, the microcontroller reduces its level of power consumption.

Summary of the Invention

The present invention relates to a remote utility meter monitoring system and methods of use thereof. The remote utility meter monitoring system comprises a central or host computer (host) and one or more remote meter monitoring units (RMU), which may each monitor one or more electronic or solid state utility meters. The RMUs communicate with the host via a communication network.

The remote meter monitoring system provides several general advantages. First, the system reduces operating costs. For example, the system reduces the costs associated with hiring and training personnel to read data from remote meters in the field. The system also reduces the costs associated with hiring and training office personnel to compile and process the meter data. The system also minimizes the interference with customers associated with routine meter-reading visits.

The system allows more frequent customer consumption reads, such as daily, hourly or quarter-hourly reads, compared to monthly or quarterly reads by field personnel. The system also reduces human error and improves billing accuracy. The system gathers vast amounts of data, such as peak values and peak times, from a large geographical area virtually simultaneously. For example, the system allows utility companies to quickly and efficiently construct one or more load profiles for single customers, groups of customers and/or geographical areas of various sizes. Load profiles allow utility companies to control load-sharing, which reduces the need for utility companies to build additional power plants due to increased power demand. Gathering data quickly and managing consumption is particularly important for serving heavy usage customers.

For service disruptions, the system pin-points malfunctioning meters or stations without guessing their location. The system improves customer service by reducing the time it takes to detect a disruption and to restore service.

In addition to the general advantages, the remote meter monitoring system may provide several specific advantages or features. In a one embodiment, the RMU is configured to detect and report (to the host) a number of events associated with the RMU and a plurality of electronic meters coupled to the RMU. These events may include a power outage of an electronic meter, a power restoration of a meter, a meter disconnection from the RMU, a meter malfunction or tampering such as vandalism, a power outage of a particular service area associated with a meter, a power outage within the RMU, a power restoration within the RMU, and other meter alarms and events.

In one embodiment, the RMU has a modem and a modem-sharing unit which provides communication between a plurality of electronic meters and the host. Each electronic meter may be located at a substantial distance from the RMU.

In one embodiment, the RMU has its own wireless transceiver, which allows the RMU to communicate with the host via a wireless communication channel.

In one embodiment, the RMU has its own power supply and rechargeable back-up battery. For example, the rechargeable back-up battery enables the RMU to report the power failure or restoration of an electronic meter or the power failure of the RMU when the RMU's main power supply has failed.

In one embodiment, the RMU has an intelligent line-sharing unit, which shares a customer's telephone line without interrupting the customer's incoming, outgoing or ongoing calls. The line-sharing unit gives priority to any call originated by the customer. The customer is unaware of the line-sharing, i.e., the communication between the RMU and the host is transparent to customer.

In one embodiment, when the RMU detects an event associated with the meters or the RMU itself, the RMU automatically dials a pre-stored telephone number to report the event to the host. If an event is associated with a meter, the RMU may report the serial number or a pre-stored, pre-determined identification number of that meter to the host. In addition, the RMU may report the event itself. If an event is associated with the RMU, the RMU may report the serial number or an identification number of the RMU to the host and the event itself.

In one embodiment, the RMU waits a predetermined time period, such as thirty seconds or two minutes, before reporting an event to the host. If the event, such as a power outage or power restoration, has not changed at the end of the time period, then the RMU reports the event to the host. If the event has changed, e.g., a recovery, at the end of the time period, then the RMU does not report the event to the host. Alternatively, in another embodiment, if the event changes anytime during the time period, then the time period is reset.

One advantage of the predetermined time period is that a condition of a meter, such as a power outage, detected in a time sample (e.g., one second) may be disregarded by the RMU if the condition changes at some point before the end of the predetermined time period (e.g., two minutes). For example, a meter may temporarily lose power

or function improperly and then regain power or function properly before the end of the predetermined time period. The ability to disregard false or momentary conditions improves the reliability of the RMU.

In one embodiment, the RMU reports power outages, malfunctions and disconnections to a communication device, such as a pager, a wireless phone, a fax machine, etc., instead of or in addition to the host.

In one embodiment, the RMU continuously tests the meters coupled to the RMU for power outage or power restoration by strobing or stepping through each port associated with a meter in sequence at a relatively high frequency. In one configuration, the RMU scans one port for a predetermined time sample and then scans the next port for the same time sample.

In one embodiment, the RMU and/or the meter reports events prior to a power outage, such as a voltage sag or a current spike, to the host. If the power outage has not yet occurred, these events may allow the host to alert utility company personnel to investigate the event and thereby prevent the power outage. For example, if a tree falls on a power line, a meter near the tree may indicate a voltage sag or leakage. After the RMU reports the voltage sag or leakage to the host, the host may alert utility company personnel to remove the tree. If the power outage already occurred, the host may use the reported events prior to the power outage to try to determine the reason why the power outage occurred.

In one embodiment, the RMU waits a first predetermined time period, such as 5 seconds, for an acknowledgement signal from the host after the RMU sends a report or alarm message. If the RMU does not receive an acknowledgement character, the RMU resends the report or alarm message. In one embodiment, after a predetermined number of failed attempts, the RMU retries after a second predetermined time period, such as two minutes.

In one embodiment, the RMU is configured to receive and respond to requests for information from the host. The requested information may include the meter serial/identification numbers, the identification number of the RMU and the current alarm status of each meter and the RMU. The host may send commands to the RMU, such as a command to store, change or verify a dial-out phone number. The central computer may also send commands to the meters, such as a command to change the frequency of the meter readings.

In one embodiment, the RMU has a connector for loading or downloading information from a laptop or other portable device. The loaded or downloaded information may include a dial-out phone number, a back-up dial-out phone number, serial numbers of meters, an ID number of the RMU, and configuration parameters for an internal modem.

In one embodiment, the RMU can differentiate an electronic meter with a power outage from an electronic meter which is in an idle mode. In a large number of electronic meters, when the meter is not transmitting or receiving data, the meter does not generate an active signal to indicate whether the meter is in idle mode or whether the meter has lost its power or malfunctioned. The RMU has a detector which is configured to detect a low-level noise signal or footprint generated by the meter when the meter is in idle mode. This is particularly advantageous where the RMU is monitoring a plurality of meters, and one meter loses power or has a component which malfunctions.

In one embodiment, the RMU can advantageously differentiate power outage from idle mode for one or more meters which are located at an extended distance from the RMU.

In one embodiment, the detector is disabled when at least one of the meters is transmitting data to the host (through the remote monitoring unit) or receiving data from the host (through the remote monitoring unit). Alternatively, in another embodiment, the detector continues to scan the other meters which are not currently transmitting or receiving data.

One aspect of the invention relates to a remote meter monitoring system. The system comprises a central computer, at least one remote meter monitoring unit and at least one electronic meter, which is coupled to the remote monitoring unit. The remote monitoring unit is configured to communicate with the central computer over a communication network. The remote monitoring is configured to detect a noise signal or footprint generated by the meter when the meter is functioning properly and the meter is properly coupled to the remote monitoring unit. The remote monitoring unit sends a signal to the central computer when the detector detects a change in the noise signal from the meter.

Another aspect of the invention relates to a remote meter monitoring unit. The remote monitoring unit is coupled to an electronic meter. The remote monitoring unit communicates with a central computer via a communication network. The remote monitoring unit is configured to detect a noise signal or footprint generated by the electronic meter when the meter is functioning properly and the meter is properly coupled to the remote monitoring unit. If the remote monitoring unit detects a change in the noise signal, the remote monitoring unit sends a signal to the central computer. The signal may notify the central computer that the meter has lost power, restored power, malfunctioned or been disconnected from the remote monitoring unit.

Another aspect of the invention relates to a method of remotely monitoring an electronic meter. The method comprises scanning a line, which is coupled to an electronic meter. The method further comprises detecting a noise signal or footprint, which is generated by the meter when the meter is functioning properly, and the meter is properly coupled to a remote monitoring unit. The method further comprises sending a signal to a host computer if a change in the noise signal is detected.

Brief Description of the Drawings

Figure 1 illustrates a remote meter monitoring system in accordance with one embodiment of the present invention.

Figure 2 illustrates one embodiment of a meter within the remote meter monitoring system of Figure 1.

Figure 3 illustrates another embodiment of a meter within the remote meter monitoring system of Figure 1.

Figure 4 illustrates one embodiment of a remote monitoring unit within the remote meter monitoring system of Figure 1.

Figure 5 illustrates another embodiment of a remote monitoring unit within the remote meter monitoring system of Figure 1.

Figure 6 illustrates another embodiment of a remote monitoring unit within the remote meter monitoring system of Figure 1.

Figure 7 illustrates another embodiment of a remote monitoring unit within the remote meter monitoring system of Figure 1.

Figure 8 illustrates one embodiment of a detector within a remote monitoring unit within the remote meter monitoring system of Figure 1.

Figure 9 illustrates one embodiment of a method of detecting and reporting a noise signal or footprint from a plurality of meters.

Figure 10 is a circuit diagram of one embodiment of the remote monitoring unit within the remote meter monitoring system of Figure 1.

Figure 11 is a circuit diagram of one embodiment of a power supply associated with the remote monitoring unit of Figure 10.

Detailed Description of the Preferred Embodiment

The present invention relates to a remote meter monitoring system and methods of use thereof. In the description below, the system is described with an electric or power utility system. The system may be configured to monitor other electronic devices, such as gas meters or water meters. The system is particularly suited to monitor a plurality of electronic devices. The system is also particularly suited to monitor a plurality of electronic devices that are at a substantial distance from each other or at a substantial distance from a remote monitoring unit which is coupled to the plurality of electronic devices.

Figure 1 illustrates a remote meter monitoring system 100 in accordance with one embodiment of the present invention. The system 100 comprises a first electronic meter 102, a second electronic meter 104, a third electronic meter 106, a remote meter monitoring unit (RMU) 164, a communication network 110 and a central or host computing system ('host') 112. The system 100 may be associated with a customer communication device 114 and another communication device 116.

The first meter 102 is coupled to a power line associated with a first customer 140. The second meter 104 is coupled to a power line associated with a second customer 142. The third meter 106 is coupled to a power line associated with a third customer 144. The first meter 102 is coupled to the RMU 164 via a first cable or line 166. The second meter 104 is coupled to the RMU 164 via a second line 168. The third meter 106 is coupled to the RMU 164 via a third line 170.

In Figure 1, the RMU 164 may be configured to operate with any number of meters. In one embodiment, the RMU 164 has eight ports for eight separate meters to be coupled to the RMU 164. In another embodiment, the RMU 164 has 32 ports for 32 separate meters to be coupled to the RMU 164. An expansion unit or a connector (not shown) may be used to increase the number of meters 102-106 coupled to the RMU 164.

The Lines Between the Meters and the RMU

In Figure 1, the first, second and third lines 166-170 may comprise one or more different types of data lines. In one embodiment, one or more lines 166-170 are standard RS-232 digital data lines. In another embodiment, one or more lines 166-170 are standard RS-485 data lines. In another embodiment, one or more lines 166-170 comprise a current loop. In another embodiment, one or more lines 166-170 are non-standard lines. The lines 166-170 transfer signals between the meters 102-106 and the RMU 164.

In Figure 1, a preferred embodiment of the RMU 164 is configured such that the meters 102-106 can be located at an extended distance from the RMU, such as 50 feet, 200 feet, 500 feet or farther. Thus, the first, second and third lines 166-170 may be 500 feet or longer. For example, the meters 102-106 may be associated with stores in a strip mall. Alternatively, the meters 102-106 may be associated with an apartment complex, an industrial park, a business center, etc. The distance between the meters 102-106 and the RMU 164 may depend on the size of the stores, apartments, apartment buildings, industrial buildings, offices, etc.

The variable distance of the lines 166-170 may also allow a single RMU 164 to service a number of meters 102-106 which are located at a relatively large distance from each other. For example, the distance between two meters 102, 104 may be 1000 feet. One RMU 164 may be able to service both meters with lines of 500 feet or more to each meter. Furthermore, the variable distance of the lines 166-170 allows the RMU 164 to be placed at a location which may advantageously minimize the risk of tampering or harmful conditions

In Figure 1, the customer communication device 114 may be a standard telephone line coupled to a computer, modem, fax machine, or any electronic device for voice transmissions, facsimile or Internet access.

The Communication Network

In Figure 1, the communication network 110 may comprise a standard public switching telephone network (PSTN), a cable-based network, a wireless communication network or some combination thereof. The wireless communication network may be a public or private network. The wireless communication network may use, for example, code division multiple access (CDMA), time division multiple access (TDMA) or frequency division multiple access (FDMA).

In Figure 1, the host 112 comprises at least one microprocessor and software for managing meter readings, alarm conditions and other data transmitted by the meters 102-106.

The Meters

Figure 2 illustrates one embodiment of a meter 102 within the remote meter monitoring system 100 of Figure 1. In Figure 2, the meter 102 comprises a non-volatile memory 146, a microcontroller 148, a power supply 156 and an isolator 158. The microcontroller 148 is coupled to the memory 146, the power supply 156 and the isolator 158. The isolator 158 is coupled to the line 166, which couples the meter 102 to the RMU 164. In one configuration, the power supply 156 and/or the microcontroller 148 are loosely, capacitively coupled to the isolator 158 and the line 166. In one embodiment, the meters 102-106 are electronic AlphaMeters manufactured by ABB.

In Figure 2, the microcontroller 148 reads the amount of power consumed (usage) or current drawn by the customer 140 at all times or at predetermined times during a day. For example, the predetermined times may be 15 minutes apart, 15 seconds apart or 15 milliseconds apart. The predetermined time period is stored in the memory 146. In one configuration, the meter 102 reads the AC power at a peak in a cycle. In one configuration, the power is measured in kilowatts. The microcontroller 148 records some or all of the power consumption readings in the memory 146. The microcontroller 148 may also store the peak consumption level(s), the time(s) of peak consumption, any disruption or distortion to the power line, over-heating of a nearby transformer, etc. in the memory 146.

In one embodiment, the microcontroller 148 at predetermined times transfers data stored in the memory 146 to the RMU 164, which transmits the data to the host 112 (Figure 1). The data rate of transfer from the meter 102 to the RMU 164 may be 14400, 9600, 4800, 2400 or 1200 bits per second, asynchronous. The amount of data stored in the memory 146 and the frequency of the meter reads may depend on the size of the memory 146 and the configured frequency of reporting data to the host 112. After the data is reported to the host 112, portions of the memory 146 may be erased, and new data may be stored in the memory 146.

In one embodiment, the meter 102 of Figure 2 is configured to receive data and commands from the host 112. One command from the host 112 to the meter 102 may be a request to transfer data from the meter 102 to the host 112. Another command from the host 112 may be to change the frequency of reading and storing the customer's power consumption. Another command may be to change the frequency of sending data (reports) stored in the memory 146 to the host 112. Another command may be to report the serial number of the meter 102, which is stored in the memory 146, to the host 112.

In Figure 2, the power supply 156 of the meter 102 supplies power to the microcontroller 148. In one configuration, the power supply 156 is a switching power supply, which converts alternating current (AC) from the power source shown in Figure 2 to direct current (DC). The isolator 158 isolates the line 166 from power surges, such as a power surge that results from lightning striking a power line associated with the customer 140. In one configuration, the isolator 158 is an opto-isolator. In another configuration, the isolator 158 is a transformer isolator.

Idle Mode And Noise

In Figure 2, the meter 102 is in an idle mode when the meter 102 is not transmitting data (e.g., meter readings) or receiving data (e.g., a command from the host 112 to change the frequency of meter readings) from the RMU 164. As used herein, the phrase 'idle mode' refers broadly to a stand-by mode, a sleep mode or a dormant mode. In one embodiment, the meter 102 may read power consumption levels and store power readings or other data while the meter is in idle mode. In idle mode, a meter's power consumption and microprocessor activity are typically reduced.

In idle mode, the meter 102 does not generate an active signal to the RMU 164 to indicate whether the meter 102 is in idle mode or whether the meter has lost power, malfunctioned or been disconnected. When the meter 102 is in idle mode and functioning properly with power, the meter 102 generates or radiates a passive, low-level noise signal (also referred to herein as a noise footprint or signature).

In one configuration, the power supply 156, such as a switching power supply, generates the low-level noise. In another configuration, the microcontroller 148 or a component of the microprocessor 148, such as an internal clock or an oscillator, generates the low-level noise. In one embodiment, the clock keeps the microprocessor 148 in idle mode. In another configuration, both the power supply 156 and the microcontroller 148 generate the low-level noise. In one configuration, the low-level noise is electromagnetic interference (EMI). The low-level noise may be in millivolts or microvolts.

The isolator 158 is not configured to block this low-level noise from leaking either directly or indirectly onto the line 166. Thus, at least some of the low-level noise leaks onto the line 166 and into the RMU 164. The meter 102 generates the low-level noise in both idle mode and non-idle mode.

When the meter 102 loses its power or some component within the meter 102 is not operating properly, the meter 102 ceases to generate the same low-level noise when the meter 102 has power and the meter components are operating properly. Likewise, if the meter 102 is disconnected from the line 166, then the noise ceases to leak onto the line 166 to the RMU 164.

Figure 3 illustrates another embodiment of a meter 102' within the remote meter monitoring system 100 of Figure 1. In Figure 3, the meter 102 comprises a memory 146, a microcontroller 148, a modem 150 and a power supply 156. The structure and function of the meter 102' in Figure 3 is substantially similar to the structure and the function of the meter 102 shown in Figure 2, except the meter 102' in Figure 3 further comprises a modem 150.

Figure 4 RMU Embodiment

Figure 4 illustrates one embodiment of a RMU 108 within the remote meter monitoring system 100 of Figure 1. In Figure 4, the RMU 108 comprises a wireless transceiver 128, a line-sharing unit 123, a multiplexer 129, a detector 130, a power supply 120 and a back-up battery 136. In Figure 4, the meters 102', 104', 106' comprise internal modems similar to the meter 102' shown in Figure 3.

In Figure 4, the line-sharing unit 123 is coupled to the first, second and third meters 102', 104', 106', the detector 130 and the wireless transceiver 128. The detector 130 is also coupled to the wireless transceiver 128. The power supply 120 is coupled to an external power source and the back-up battery 136. The power supply 120 and the back-up battery 136 are coupled to the wireless transceiver 128, the multiplexer 129, the detector 130 and the line-sharing unit 123. The multiplexer 129 is coupled to the meters 102', 104', 106' and the detector 130.

In Figure 4, the RMU 108 may further comprise an omni-directional, wireless transceiver antenna (not shown), which is coupled to the wireless transceiver 128. In one embodiment of the RMU 108 shown in Figure 4, the line-sharing unit 123 includes the detector and a multiplexer.

In Figure 4, in one embodiment, the wireless transceiver 128 is a Motorola S5690B transceiver with a data interface module. In one embodiment, the battery 136 is a rechargeable, lead-acid battery. In one embodiment, the power supply 120 is a wide input voltage range, 90-277 VAC isolated, switching power supply. Specifically, the power supply 120 receives about 90 to about 277 VAC at about 50 to about 60 Hz from a power source and outputs

about 13.2 volt DC at full load. Alternatively, in another embodiment, the power supply 120 is a 110-220 VAC power supply. The power supply 120 may charge the back-up battery 136.

The RMU 108 of Figure 4 is configured to operate with meters 102'-106' with their own modems, such as the meter 102' shown in Figure 3. In Figure 4, the line-sharing unit 123 advantageously allows multiple meters 102'-106' to communicate with the host 112 one at a time by using the same wireless transceiver 128. In one embodiment, the line-sharing unit 123 comprises a multiplexer.

Figure 5 RMU Embodiment

Figure 5 illustrates another embodiment of a RMU 160 within the remote meter monitoring system 100 of Figure 1. In Figure 5, the RMU 160 comprises a modem 124, a modem-sharing unit 126, a line-sharing unit 122, a multiplexer 129, a detector 130, a power supply 120 and a back-up battery 136. The modem 124 comprises a microprocessor 118, a memory 132 and other components typically associated with a modem which converts data for transmission via a public switching telephone network 110. The microprocessor 118 includes a timer 138, and the memory 132 stores firmware 134.

In Figure 5, the first, second and third meters 102-106 are coupled to lines 166-170 respectively, which are coupled to the modem-sharing unit 126 and the multiplexer 129. The modem-sharing unit 126 is coupled to the modem 124, which is coupled to the line-sharing unit 122 and the detector 130. The line-sharing unit 122 is coupled to a customer telephone line 114 and the PSTN 110 with RJ-11 connectors. The power supply 120 is coupled to an external power source and the back-up battery 136. The power supply 120 and the back-up battery 136 are coupled to the line-sharing unit 122, the modem 124, the multiplexer 129, the detector 130 and the modem-sharing unit 126. The multiplexer 129 is coupled to the detector 130.

In Figure 5, the modem-sharing unit 126 has an interface unit which receives data from the meters 102-106. In one embodiment, the modem-sharing unit 126 has a multiplexer and a plurality of RJ-11 modular jack connectors. The modem-sharing unit 126 advantageously allows multiple meters 102-106 to communicate with the host 112 one at a time by using the same modem 124. The modem-sharing unit 126 may convert data from the meters 102-106 to a data stream, multiplex the data, and otherwise prepare the data to be received by the modem 124. The modem-sharing unit 126 may also transmit data and commands from the host 112 to each meter 102-106.

In Figure 5, the modem 124 is preferably an integrated, high-speed, AT command set compatible, V.32bis modem which allows speeds of about 1200 to about 14,400 bits per second (bps). In one embodiment, the modem is manufactured by Telenetics in Lake Forest, CA. In one embodiment, some of the components of the modem 124, such as the microprocessor 118 and the memory 132, are based on a 14400 bps modem microchip set manufactured by Rockwell (now known as Conexant) in California. In one embodiment, additional components and/or additional firmware are added to the microchip set manufactured by Rockwell to accomplish the functions as described herein.

In Figure 5, the memory 134 stores the serial numbers or predetermined identification numbers of the meters 102-106 that are coupled to the RMU 164 and an identification number of the RMU 164. The memory 134 also stores a dial-out number to reach the host 112. The firmware 134 is stored in the memory 132 and executed by the

microprocessor 118. The firmware 134 preferably performs standard operations of a modem, such as converting serial data to audio signals, as well as other operations as described herein.

In general, each meter 102-106 may initiate a data transfer to the host 112. The RMU 160 may initiate a communication to the host 112. The host 112 may initiate a data request or command to the RMU 160 and/or the meters 102-106.

When the host 112 has a command to send to one or more meters 102-106, the host 112 embeds the ID number of the desired meters in the command. In one embodiment, the modem-sharing unit 126 of the RMU 160 passes the command to all of the meters 102-106 and each meter determines whether the command was addressed to that particular meter. Only the meters which were addressed by the host 112 respond to the command from the host 112.

Line-Sharing

In Figure 5, in one embodiment, the line-sharing unit 122 is based on a relay-switching line-sharing board (0050 or 0050-1156-000) made by Telenetics. In one embodiment, the functions of the line-sharing unit 122 described below are controlled by the firmware 134 and the microprocessor 118. In this embodiment, the line-sharing unit 122 acts as an interface between the customer line 114, the modem 124 and the PSTN 110.

In operation, the line-sharing unit 122 transmits data between the modem 124 within the RMU 160 and the host 112 by using the customer telephone line 114 when the customer telephone line 114 is not being used by the customer. The line-sharing unit 122 preferably does not interrupt a customer's outgoing or ongoing calls. In other words, the line-sharing unit 122 gives priority to any call originated by the customer. The customer is advantageously unaware of the communication between the RMU 160 and the host 112.

Specifically, the line-sharing unit 122 is configured to detect whether the customer's telephone line 114 is on-hook or off-hook. If the line 114 is off-hook, i.e., the customer is using the line 114, the line-sharing unit 122 blocks any communication between the host 112 and the modem 124. If the line 114 is on-hook, the line-sharing unit 122 allows the host 112 and the modem 124 to communicate with each other. If the line 114 is off-hook when the host 112 initiates a call, the host 112 will receive a busy signal and try again after a predetermined time period. Likewise, if the line 114 is off-hook when the modem 124 initiates a call, the modem 124 will try to communicate with the host 112 again after a predetermined time period. Alternatively, the line-sharing unit 122 may send a signal to the modem 124 which informs the modem 124 when the line 114 is once again on-hook. The modem 124 then initiates a call.

If communication between the host 112 and the modem 124 is in progress, and the line 114 becomes off-hook (i.e., the customer picks up the phone), the line-sharing unit 122 interrupts and ceases communication between the host 112 and the modem 124. The customer may start and complete a call. After the line 114 returns to on-hook, either the host 112 or the modem 124 may try to re-establish communication by initiating another call.

In one embodiment, the line-sharing unit 122 responds to a programmable security code or password from the host 112 to access the modem 124. For example, in one configuration, when the line-sharing unit 122 receives a

call from the network 110, the line-sharing unit 122 is configured to detect a predetermined dual-tone multi-frequency (DTMF) sequence, such as a two-digit sequence like '*' and '7.' If the line-sharing unit 122 does not detect the predetermined DTMF sequence within a predetermined time period, such as five seconds, the line-sharing unit 122 transfers the call to the customer telephone line 114. In one embodiment, the line-sharing unit 122 has a ring generator which generates a ring to alert the customer of an incoming call. If the line-sharing unit 122 detects the predetermined DTMF sequence, then the line-sharing unit 122 directs the call to the modem 124.

Figure 6 RMU Embodiment

Figure 6 illustrates another embodiment of a RMU 162 within the remote meter monitoring system 100 of Figure 1. In Figure 6, the RMU 162 comprises a wireless transceiver 128, a modem 124, a modem-sharing unit 126, a multiplexer 129, a detector 130, a power supply 120 and a back-up battery 136. The modem 124 comprises a microprocessor 118, a memory 132 and other components typically associated with a modem which converts data for transmission via a wireless network 110. The microprocessor 118 includes a timer 138, and the memory 132 stores firmware 134.

In Figure 6, the first, second and third meters 102-106 are coupled to lines 166-170 respectively, which are coupled to the modem-sharing unit 126 and the multiplexer 129. The modem-sharing unit 126 is coupled to the modem 124, which is coupled to the wireless transceiver 128 and the detector 130. The power supply 120 is coupled to an external power source and the back-up battery 136. The power supply 120 and the back-up battery 136 are coupled to the wireless transceiver 128, the modem 124, the multiplexer 129, the detector 130 and the modem-sharing unit 126. The RMU 162 in Figure 6 may further comprise an omni-directional, wireless transceiver antenna (not shown), which is coupled to the wireless transceiver 128. The multiplexer 129 is coupled to the detector 130.

In Figure 6, the structures and functions of the wireless transceiver 128, the modem 124, the modem-sharing unit 126, the power supply 120 and the back-up battery 136 are substantially similar to the structures and functions described above.

Figure 7 RMU Embodiment

Figure 7 illustrates another embodiment of a RMU 164 within the remote meter monitoring system 100 of Figure 1. In Figure 7, the RMU 164 comprises a wireless transceiver 128, a modem 124, a modem-sharing unit 126, a line-sharing unit 122, a detector 130, a multiplexer 129, a power supply 120 and a back-up battery 136. The modem 124 comprises a microprocessor 118, a memory 132 and other components which convert data for transmission via a communication network 110, such as a wireless network or a PSTN. The microprocessor 118 includes a timer 138, and the memory 132 stores firmware 134.

In Figure 7, the first, second and third meters 102-106 are coupled to lines 166-170 respectively, which are coupled to the modem-sharing unit 126 and the multiplexer 129. The multiplexer 129 is coupled to the modem 124 and the detector 130, which is also coupled to the modem 124. The modem-sharing unit 126 is coupled to the modem 124, which is coupled to the wireless transceiver 128 and the line-sharing unit. The power supply 120 is coupled to an external power source and the back-up battery 136. The power supply 120 and the back-up battery 136 are

coupled to the wireless transceiver 128, the modem 124, the line-sharing unit 122, the modem-sharing unit 126, the multiplexer 129 and the detector 130.

The RMU 164 in Figure 7 may further comprise an omni-directional, wireless transceiver antenna (not shown), which is coupled to the wireless transceiver 128. In Figure 7, the structures and functions of the wireless transceiver 128, the modem 124, the modem-sharing unit 126, the line-sharing unit 122, the power supply 120 and the back-up battery 136 are substantially similar to the structures and functions described above.

In general, the RMU 164 of Figure 7 is configured to operate with meters with their own modems, such as the meter 102' shown in Figure 3, or meters without their own modems, such as the meter 102 shown in Figure 2. Furthermore, the RMU 164 of Figure 7 may share a customer telephone line, such as the customer telephone line 114 described above with reference to Figure 5, or use a wireless transceiver, such as the wireless transceiver 128 described above with reference to Figure 4.

In Figure 7, the microprocessor 118 uses the multiplexer 129 to select one of the lines 166-170 at a time to be scanned by the detector 130.

Noise Detector

Figure 8 illustrates one embodiment of a detector 130 that may be incorporated in the RMUs 108, 160, 162, 164 shown in Figures 1, 4, 5, 6 and 7. For the sake of efficiency, the detector 130 is described below with reference to the RMU 164 of Figure 7.

In Figure 8, the detector 130 comprises a filter 172, an amplifier 174, a rectifier/filter 180, a comparator 176 and a reference value or pattern 178. In one embodiment, the reference value or pattern 178 is stored in a memory, such as the memory 132 in Figure 7. In one embodiment, the filter 172 is a bandpass filter. In one embodiment, the filter 172 comprises an inductor and a capacitor. The filter 172 is coupled to the amplifier 174, which is coupled to the rectifier 180. The rectifier 180 is coupled to the comparator 176, which is coupled to a microprocessor, such as the microprocessor 118 in Figure 7.

In operation, the RMU 164 provides a drive current along lines 166-170 to read signals, such as data or low-level noise, from the meters 102-106. The multiplexer 129 selects one of the lines 166-170 to be scanned by the detector 130, one at a time. For example, the multiplexer 129 may select the first line 166 upon start-up of the detector 130. In one embodiment, the multiplexer 129 only selects a line associated with meter which is not transmitting or receiving data to or from the host 112.

In Figure 8, the filter 172 of the detector 130 filters a low-level noise footprint or signal generated by the meter 102 when the meter 102 has power, as described above with reference to Figures 2-3. In Figure 8, the filter 172 passes the low-level noise to the amplifier 174.

In one embodiment, a spectrum analyzer is used to determine the characteristics (e.g., bandwidth) of one or more low-level noise signals generated by the meter 102 when the meter 102 has power. Different types of meters may have different noise signals with different characteristics. Based on the characteristics found by the spectrum analyzer, the filter 172 may be configured to filter at least one of the low-level noise signals. In one embodiment, the

characteristics (e.g., bandwidth) are selected based on the combined noise generated by the power supply 156 and the microcontroller 148. In one configuration, the frequency bandwidth of the low-level noise filtered by the filter 172 and passed to the amplifier 174 is about 1-2 megahertz (MHz). In other configurations, other frequency bandwidths may be used.

In one embodiment, a single filter 172 is user-configurable to filter different bandwidths from different types of meters. Alternatively, in another embodiment, one or more filters are selected during manufacture to filter low-level noise within a particular bandwidth for a particular type of meter 172. In yet another embodiment, the detector 130 comprises another component in addition to or instead of the filter 172 to detect the low-level noise signal on the line 166.

In addition to the noise generated by the meter 102, there may be noise from sources other than the meter 102 which are detected by the detector 130 along the line 166. In a preferred embodiment, the noise from sources other than the meter 102 does not significantly affect the low-level noise signal from the meter 102, which is passed by the filter 172 to the amplifier 174. In one embodiment, the frequency of the low-level noise signal is substantially higher than the frequency of the noise from sources other than the meter 102. In one configuration, the low-level noise signal from the meter 102 is about 1-2 MHz. In one configuration, the noise from sources other than the meter 102 is about 100 kilohertz (KHz).

In Figure 8, the amplifier 174 receives and amplifies the filtered low-level noise from the filter 172. The amplifier 174 then passes the amplified noise to rectifier/filter 180, which rectifies the noise signal. The rectifier 180 transfers the amplified, rectified, filtered noise signal to the comparator 176. The comparator 176 compares the amplified, rectified noise signal with a predetermined value, such as a reference voltage value or pattern 178. The comparator 176 determines whether the amplified, rectified noise is lower, higher or substantially matches the predetermined value or pattern 178.

In one embodiment, the comparator 176 is configured such that if the amplified, rectified noise is lower than the predetermined value or pattern 178, the comparator 176 sends a signal to the microprocessor 118. In another embodiment, the comparator 176 is configured such that if the amplified, rectified noise is higher than the predetermined value or pattern 178, the comparator 176 sends a signal to the microprocessor 118. In another embodiment, the comparator 176 is configured such that if the amplified, rectified noise matches than the predetermined value or pattern 178, the comparator 176 sends a signal to the microprocessor 118.

In general, the comparator 176 determines whether the meter 102 has power, is functioning properly and is connected to the line 166 based on the amplified, rectified signal from the rectifier/filter 180. The comparator 176 then sends a signal to the microprocessor 118.

In one embodiment, the comparator 176 sends a binary, one-bit signal to the microprocessor 118. For example, in one configuration, the comparator 176 sends a '1' when the detected noise matches the predetermined value or a '0' when the detected noise signal does not match the predetermined value. In one embodiment, the '1' bit

signifies a meter has power, is functioning properly and is connected to the line 166, and the '0' bit signifies a meter has lost power, is not functioning properly or is not connected to the line 166.

In another embodiment, the comparator 176 sends a two-bit value to the microprocessor 118. For example, the comparator 176 may send the following signals to the microprocessor 118:

'00' -- the noise matches the predetermined value, which indicates the meter has power, is functioning properly and is properly connected;

'01' -- the noise does not match the predetermined value, which indicates the meter is losing power or is malfunctioning;

'11' -- there is no noise at all, which indicates the meter 102 has been disconnected from the line 166.

In one embodiment, the detector 130 scans the line 166 for a predetermined time sample. The detector 130 looks for the low-level noise within this sample. In one configuration, the sample is one second in duration.

Alternatively, in another embodiment, the detector 130 detects events prior to a power outage, such as a voltage sag or a current spike, to the host. For example, the comparator 176 may compare the noise to a number of different predetermined reference values. Each reference value may have an assigned event. If a detected noise signal substantially matches one of the reference values, then the comparator 176 informs the microprocessor which event occurred.

In Figure 7, when the detector 130 detects a change in the noise value from a meter 102, the detector notifies the microprocessor 118. The microprocessor 118 then sends a signal or message to the host 112 by using the modem 124 and the line-sharing unit 122 or the wireless transceiver 128. In one embodiment, the format of the RMU 164 reports to the host is in DTMF. In another embodiment, the format of RMU 164 reports is in ASCII text messages. In one embodiment, the RMU 164 sends reports to another communication device 116 (Figure 1), such as a pager, a wireless phone, a fax machine, etc. instead of or in addition to the host 112.

In addition to power outages, malfunctions and disconnections of the meter 102, the microprocessor 118 may report power restorations to the host 112. In other words, where a noise signal or footprint is detected from a meter 102 which previously did not generate a noise signal, then the microprocessor 118 may report that the meter 102 has restored power. Furthermore, the RMU 164 may send a report to the host 112 which indicates a power outage within the RMU 164 itself. When the RMU 164 sends a report to the host 112 which indicates a power outage within the RMU 164, the RMU 164 may be relying on the back-up battery 136 (Figure 7) for power.

<u>Noise Detection and Reporting for Multiple Meters</u>

Figure 9 illustrates one embodiment of a method of detecting and reporting a noise signal or footprint from a plurality of meters. The method of Figure 9 is described with reference to Figures 7 and 8, but the method of Figure 9 may be performed by any of the RMU embodiments shown in Figures 4-6. For the RMU embodiment shown in Figure 7, the specific process and decision blocks of Figure 9 described below may be performed by the multiplexer 129, the detector 130, the modem-sharing unit 126, the microprocessor 118, the firmware 134, other components within the modem 124, the line-sharing unit 122, the wireless transceiver 128, and/or any combination thereof.

In Figure 9, in a start block 200, the detector 130 of Figures 7 and 8 is powered on and enabled. In a process block 202, the detector 130 scans the first meter 102 for a noise signal within a sample time period, such as one second. In a decision block 204, the detector 130 determines whether a noise signal is present and whether the noise signal matches (or is above or below, depending on the configuration) the predetermined reference value 178 or pattern (Figure 8). If no matching noise signal is found, the microprocessor 118 determines if a timer (with a predetermined time period) associated with the meter 102 has been set in a decision block 212. The timer may be the timer 138 within the microprocessor 118 (Figure 7) or a timer (not shown) within the detector 130. If the timer has not been set, then the microprocessor 118 sets the timer in a process block 216. In a process block 206, the microprocessor 118 uses the multiplexer 129 to select the next line 168, and the detector 130 scans the next meter 104 for a noise signal within a sample period.

In decision block 212, if the timer associated with the meter 102 has been set, then the microprocessor 118 determines whether the timer has expired in a decision block 214. If the timer has not expired, then the microprocessor 118 uses the multiplexer 129 to select the next line 168, and the detector 130 scans the next meter 104 for a noise signal within a sample period in a process block 206. If the timer has expired, then the microprocessor 118 reports the ID number of the meter 102 with the missing noise signal to the host 112 in a process block 208. Thus, the microprocessor 118 sends a report to the host 112 if a noise signal is still missing from the meter 102 after the predetermined time period of the timer has expired.

A meter may temporarily lose power or function improperly and then regain power or function properly before the end of the predetermined time period. In one configuration, the predetermined time period of the timer is about two minutes. In one embodiment, one or more timers are used to track the start and expiration of predetermined time periods for a plurality of meters 102-106 coupled to the RMU 164.

In a decision block 210, the microprocessor 118 determines whether the report succeeded. If the report succeeded, the host 112 sends an acknowledgement signal to the RMU 164. If the report did not succeed, the microprocessor 118 sends the report again in process block 208. In one embodiment, the microprocessor 118 waits a predetermined time period between decision block 210 and the process block 208 before attempting to report the same ID number of a meter 102 with a missing noise signal to the host 112. In one configuration, the predetermined time period is 5 seconds. If the report succeeded, then the microprocessor 118 uses the multiplexer 129 to select the next line 168, and the detector 130 scans the next meter 104 for a noise signal within a sample period in a process block 206.

In the decision block 204, if a noise signal is present, the microprocessor 118 determines whether the noise was previously missing for the meter 102. In one embodiment, the microprocessor 118 compares two flags: a current status flag and a history status flag for the meter 102. If the noise signal was previously missing, then the microprocessor 118 sets a timer associated with the meter 102. The timer in process block 226 may have the same predetermined time period as the timer in process block 216. Alternatively, the two timers may have different time periods. In a preferred embodiment, the microprocessor 118 resets the timer in block 216 if the timer in block 226 is

started. In other words, the same timer is used in blocks 216 and 226. Thus, if the timer is already running, then the timer is reset by the microprocessor 118 in either blocks 216 or 226. Each meter preferably has its own associated timer.

In decision block 218, if the signal was not previously missing, then the microprocessor 220 determines whether the timer associated with the meter 102 has been set in a decision block 220. In decision block 220, if the timer has not been set, then the microprocessor 118 uses the multiplexer 129 to select the next line 168, and the detector 130 scans the next meter 104 for a noise signal within a sample period in a process block 206. In decision block 220, if the timer has been set, then the microprocessor 118 determines whether the timer has expired in a decision block 222. If the timer has not expired, then the microprocessor 118 uses the multiplexer 129 to select the next line 168, and the detector 130 scans the next meter 104 for a noise signal within a sample period in a process block 206.

In the decision block 222, if the timer has expired, then the microprocessor 118 reports the ID number of the meter 102 with the restored noise signal to the host 112 in a process block 224. In a decision block 228, the microprocessor 118 determines whether the report succeeded. If the report succeeded, the host 112 sends an acknowledgement signal to the RMU 164. If the report did not succeed, the microprocessor 118 sends the report again in process block 224. In one embodiment, the microprocessor 118 waits a predetermined time period between decision block 228 and the process block 224 before attempting to report the same ID number of a meter 102 with a missing noise signal to the host 112. In one configuration, the predetermined time period is 5 seconds. In a process block 206, the microprocessor 118 uses the multiplexer 129 to select the next line 168, and the detector 130 scans the next meter 104 for a noise signal within a sample period.

In summary, the detector 130 and the microprocessor 118 continue to scan for noise signals from the meters 102-106, and the microcontroller 118 continues to determine whether timers have started or expired. In one embodiment, the detector 130 continues to scan the meters 102-106 sequentially without stopping while the microprocessor 118 determines if a timer for a particular meter has started or expired. In one embodiment, the detector 130 is disabled when at least one of the meters 102-106 is transmitting data to the host 112 (through the RMU 164) or receiving data from the host 112 (through the RMU 164). Alternatively, in another embodiment, the detector 130 continues to scan the other meters which are not currently transmitting or receiving data.

In an alternative embodiment, the microprocessor 118 examines the number of no-noise samples for a particular meter 102 within the predetermined time period. If the number of no-noise samples for a particular meter 102 within the predetermined time period is greater than a predetermined integer, then the microprocessor 118 reports the ID number of the particular meter to the host 112. If the number of no-noise samples for a particular meter 102 within the predetermined time period is less than the integer, then the microprocessor 118 resets the timer. For example, if the number of no-noise samples for a particular meter 102 within the predetermined time period is greater than 5, then the microprocessor 118 reports the ID number of the particular meter to the host 112.

In an alternative embodiment, the RMU 164 periodically sends a test signal (in addition to the drive current) to the meter 102 and waits for the meter 102 to send a response signal back to the RMU 164. One disadvantage of this embodiment is that the test signal from the RMU 164 will probably 'wake up' the microcontroller 148 within the meter 102 (Figure 2) from idle mode to respond to the test signal from the RMU 164. This may put a drain on the power supply 156 if the meter is battery-operated, particularly if the RMU 164 sends frequent test signals to the meter 102.

Figure 10 is a circuit diagram of one embodiment of the remote monitoring unit within the remote meter monitoring system 100 of Figure 1. Figure 11 is a circuit diagram of one embodiment of a power supply associated with the remote monitoring unit of Figure 10.

The components in each RMU 108, 160, 162, 164 described herein with reference to Figures 4-7 may have some overlapping or additional parts, firmware functions, and/or features. For example, an alternative embodiment of the RMU 164 in Figure 7 has a separate microcontroller which is located external to the modem 124.

The invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiment is to be considered in all respects only as illustrative and not restrictive and the scope of the invention is, therefore, indicated by the appended claims rather than the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

WHAT IS CLAIMED IS:

1. A remote meter monitoring system comprising:

a central computer; and

a remote meter monitoring unit configured to communicate with said central computer over a communication network; said remote monitoring unit being coupled to an electronic meter, wherein said remote monitoring unit is configured to determine whether said electronic meter is functioning properly and properly coupled to said remote monitoring unit based on a noise footprint generated by said meter when said meter is functioning properly and properly coupled to the remote monitoring unit, said remote monitoring unit configured to send a signal to said central computer when said remote monitoring unit detects a change in said noise footprint from said meter.

2. A remote meter monitoring system comprising:

a central computer; and

a remote meter monitoring unit configured to communicate with said central computer over a communication network; said remote monitoring unit being coupled to an electronic meter, wherein said remote monitoring unit is configured to detect a noise footprint generated by said meter when said meter is functioning properly and said meter is properly coupled to the remote monitoring unit, said remote monitoring unit configured to send a signal to said central computer when said remote monitoring unit detects a change in said noise footprint from said meter.

3. A remote meter monitoring system comprising:

a central computer; and

a remote meter monitoring unit configured to communicate with said central computer over a communication network; said remote monitoring unit being coupled to an electronic meter, wherein said remote monitoring unit is configured to detect a noise signal generated by said meter when said meter is functioning properly and said meter is properly coupled to the remote monitoring unit, said remote monitoring unit configured to send a signal to said central computer when said remote monitoring unit detects a change in said noise signal from said meter.

4. The system of Claim 3, wherein said signal comprises a first message notifying said central computer that said meter has lost power.

5. The system of Claim 4, wherein said signal comprises a second message notifying said central computer that said meter has restored power.

6. The system of Claim 3, wherein said signal comprises a message notifying said central computer that said meter has malfunctioned.

7. The system of Claim 3, wherein said signal comprises a message notifying said central computer that said meter has been disconnected.

8. The system of Claim 4, wherein said message comprises an identification number of said meter.

9. The system of Claim 4, wherein said message comprises an identification number of said remote monitoring unit.

10. The system of Claim 3, wherein said remote monitoring unit comprises a detector, said detector comprising a filter, an amplifier, a rectifier, and a comparator.

11. The system of Claim 10, wherein said filter is a bandpass filter.

12. The system of Claim 3, wherein said remote monitoring unit further comprises a timer with a predetermined time period, said remote monitoring unit starting said timer when said remote monitoring unit detects a change in said noise signal from a first value to a second value, said remote monitoring unit sending a signal to said central computer when said remote monitoring unit detects a noise signal with said second value at an end of said predetermined time period.

13. The system of Claim 3, wherein said remote monitoring unit further comprises a timer with a predetermined time period, said remote monitoring unit starting said timer when said remote monitoring unit detects a change in said noise signal from a first value to a second value, said remote monitoring unit resetting said timer if said remote monitoring unit detects a change in said noise signal from said second value to said first value before an end of said time period, said remote monitoring unit sending a signal to said central computer when said remote monitoring unit detects a noise signal with said second value at an end of said predetermined time period.

14. The system of Claim 3, wherein said remote monitoring unit is configured to send a second signal to said central computer to report a power outage within said remote monitoring unit.

15. The system of Claim 14, wherein said second signal comprises an identification number of said remote monitoring unit.

16. The system of Claim 14, wherein said remote monitoring unit further comprises an auxiliary power supply, said auxiliary power supply supplying auxiliary power to said remote monitoring unit and allowing said remote monitoring unit to report a power outage within said remote monitoring unit.

17. The system of Claim 3, wherein said remote monitoring unit is configured to respond to a signal from said central computer by sending said identification number of said meter, a value associated with said noise signal being generated by said meter and said identification number of said remote monitoring unit to said central computer.

18. The system of Claim 3, wherein said remote monitoring unit is configured to respond to a command from said central computer to change a dial-out phone number stored at said remote monitoring unit, said remote monitoring unit using said dial-out phone number to communicate with said central computer over said communication network.

19. The system of Claim 3, wherein said electronic meter is coupled to said remote monitoring unit via a cable, said electronic meter being located at least 50 feet away from said remote monitoring unit.

20. The system of Claim 3, wherein said electronic meter is coupled to said remote monitoring unit via a cable, said electronic meter being located at least 200 feet away from said remote monitoring unit.

21. The system of Claim 3, wherein said communication network is a public switching telephone network.

22. The system of Claim 21, wherein said remote monitoring unit further comprises a modem.

23. The system of Claim 21, wherein said remote monitoring unit further comprises a line-sharing unit coupled to a customer telephone line, said remote monitoring unit communicating with said central computer via said customer telephone line.

24. The system of Claim 23, wherein said line-sharing unit is configured to detect an off-hook condition of said customer telephone line, said line-sharing unit preventing said remote monitoring unit from sending a signal to said central computer when said off-hook condition is detected.

25. The system of Claim 3, wherein said remote monitoring unit further comprises a wireless transceiver, wherein said communication network is a wireless communication channel.

26. The system of Claim 25, wherein said remote monitoring unit sends a signal to a wireless communication device when said remote monitoring unit detects a change in said noise signal from said meter.

27. The system of Claim 26, wherein said wireless communication device is a pager.

28. The system of Claim 26, wherein said wireless communication device is a wireless phone.

29. The system of Claim 3, further comprising a plurality of electronic meters coupled to said remote monitoring unit, wherein said remote monitoring unit is configured to detect a noise signal generated by each of said plurality of meters when each meter is functioning properly and said meter is properly coupled to said remote monitoring unit, said remote monitoring unit sending a signal to said central computer when said remote monitoring unit detects a change in said noise signal from one of said plurality of meters.

30. The system of Claim 29, wherein said remote monitoring unit further comprises a modem and a modem-sharing unit.

31. The system of Claim 29, wherein said electronic meters are coupled to said remote monitoring unit via cables, at least one of said electronic meters being located at least 200 feet away from said remote monitoring unit.

32. The system of Claim 29, wherein said remote monitoring unit further comprises a wireless transceiver, wherein said communication network is a wireless communication channel.

33. The system of Claim 29, wherein said remote monitoring unit scans each meter for a noise signal during a predetermined time sample, said remote monitoring unit scanning each meter one at a time sequentially.

34. The system of Claim 33, wherein said remote monitoring unit is temporarily disabled when one of said meters is transmitting data to or receiving data from said central computer.

35. The system of Claim 33, wherein said remote monitoring unit does not scan a meter which is transmitting data to or receiving data from said central computer.

36. The system of Claim 3, further comprising a plurality of remote meter monitoring units, each remote monitoring unit being configured to communicate with said central computer over a communication network,

each remote monitoring unit being coupled to at least one meter, each remote monitoring unit being configured to detect a noise signal generated by said meter coupled to said remote monitoring unit when said meter is functioning properly and said meter is properly coupled to said remote monitoring unit, each remote monitoring unit sending a signal to said central computer when said remote monitoring unit detects a change in said noise signal from said at least one meter.

37. A remote meter monitoring unit configured to communicate with a host computer over a communication network, said remote monitoring unit coupled to at least one electronic meter, wherein said remote monitoring unit is configured to detect a noise signal generated by said meter when said meter is functioning properly and said meter is properly coupled to said remote monitoring unit, said remote monitoring unit sending a signal to said host computer when said remote monitoring unit detects a change in said noise signal from said meter.

38. The system of Claim 37, wherein said signal comprises a first message notifying said central computer that said meter has lost power.

39. The system of Claim 38, wherein said signal comprises a second message notifying said central computer that said meter has restored power.

40. The system of Claim 37, wherein said signal comprises a message notifying said central computer that said meter has malfunctioned.

41. The system of Claim 37, wherein said signal comprises a message notifying said central computer that said meter has been disconnected.

42. A method of remotely monitoring an electronic meter, said method comprising:

scanning a line coupled to an electronic meter;

detecting a noise signal generated by said meter when said meter is functioning properly and said meter is properly coupled to a remote monitoring unit; and

sending a signal to a host computer if a change in said noise signal is detected.

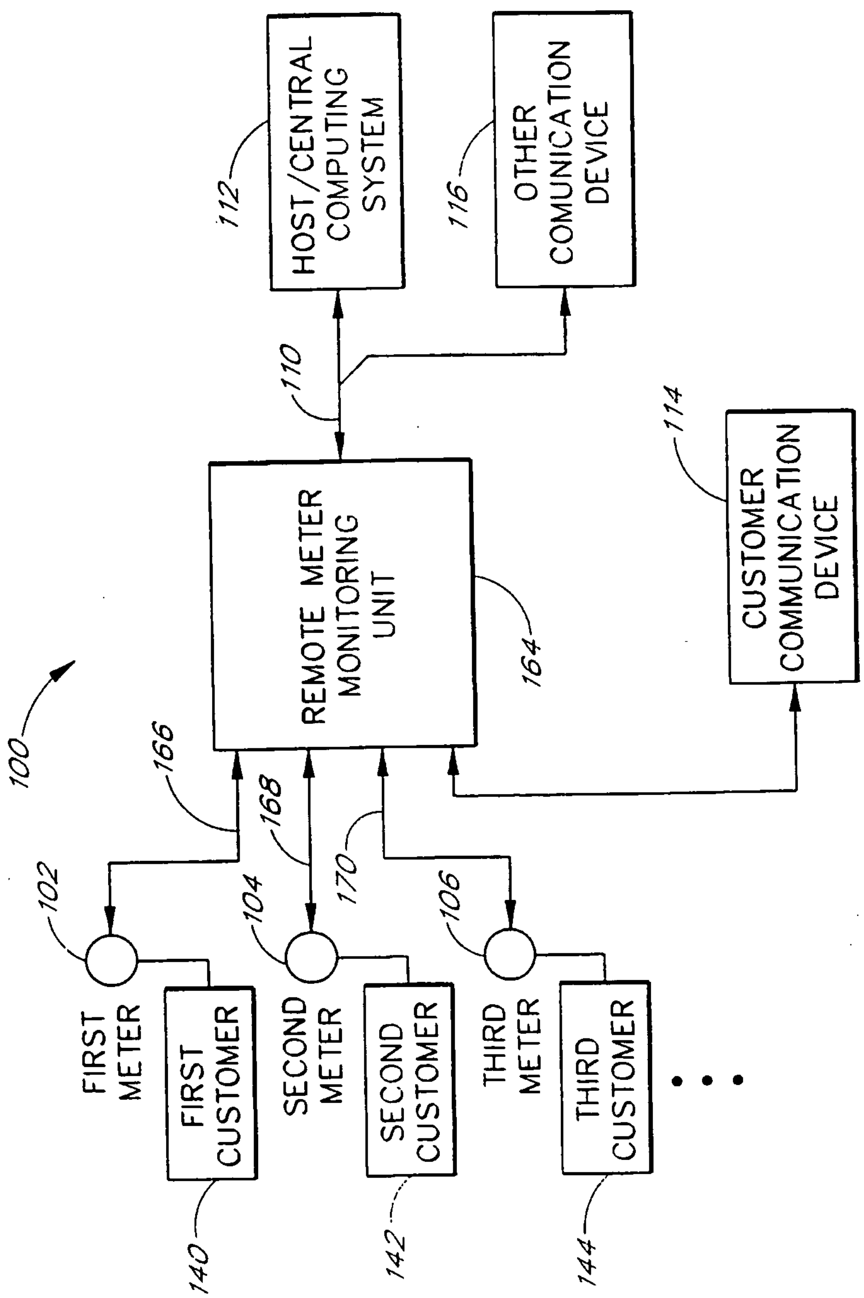

HOST/CENTRAL COMPUTING SYSTEM
112
OTHER COMUNICATION DEVICE
116
110
REMOTE METER MONITORING UNIT
164
CUSTOMER COMMUNICATION DEVICE
114
100
166
168
170
102
104
106
FIRST METER
FIRST CUSTOMER
SECOND METER
SECOND CUSTOMER
THIRD METER
THIRD CUSTOMER
140
142
144

FIG. 1

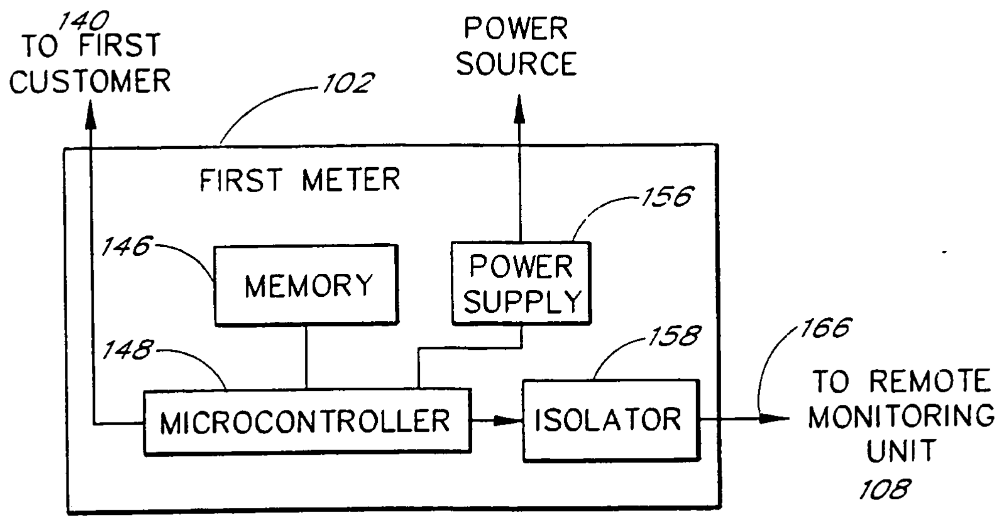

140
TO FIRST CUSTOMER
POWER SOURCE
102
FIRST METER
156
146
MEMORY
POWER SUPPLY
148
158
166
MICROCONTROLLER
ISOLATOR
TO REMOTE MONITORING UNIT
108

FIG. 2

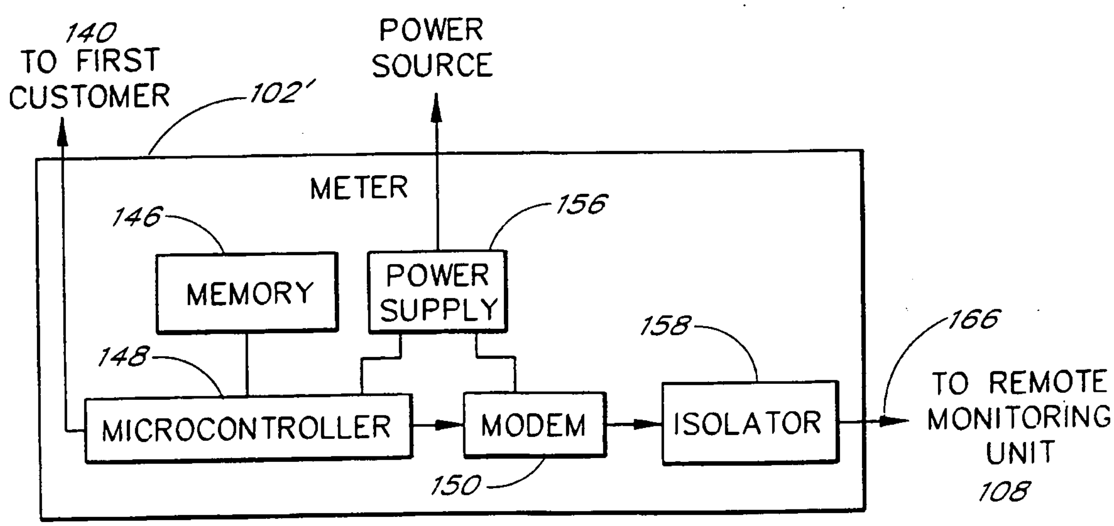

140
TO FIRST CUSTOMER
POWER SOURCE
102'
METER
156
146
MEMORY
POWER SUPPLY
158
166
148
MICROCONTROLLER
MODEM
ISOLATOR
TO REMOTE MONITORING UNIT
150
108

FIG. 3

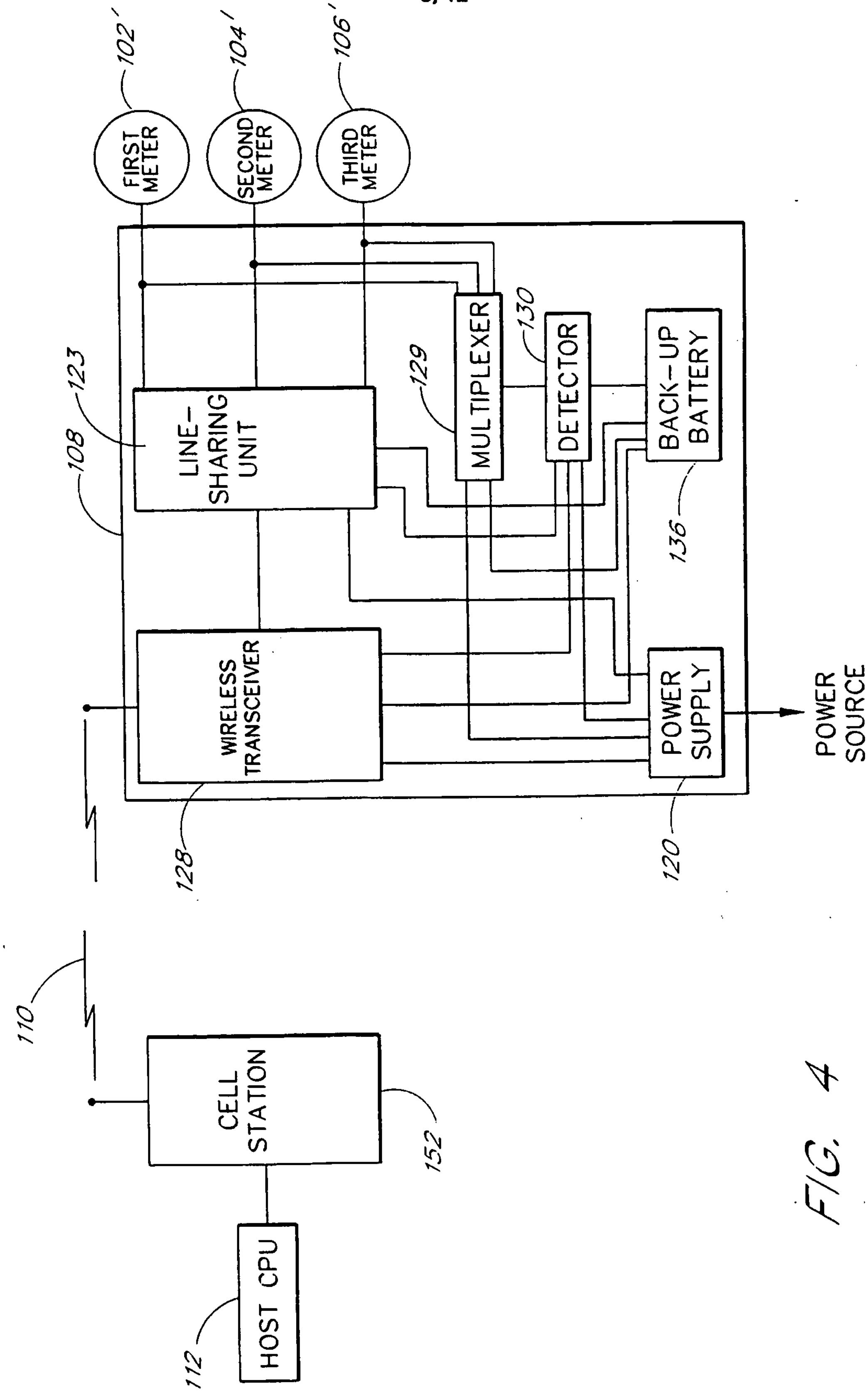

FIRST METER
SECOND METER
THIRD METER
102'
104'
106'
108
123
LINE-SHARING UNIT
MULTIPLEXER
129
DETECTOR
130
BACK-UP BATTERY
136
WIRELESS TRANSCEIVER
128
POWER SUPPLY
120
POWER SOURCE
110
CELL STATION
152
HOST CPU
112

FIG. 4

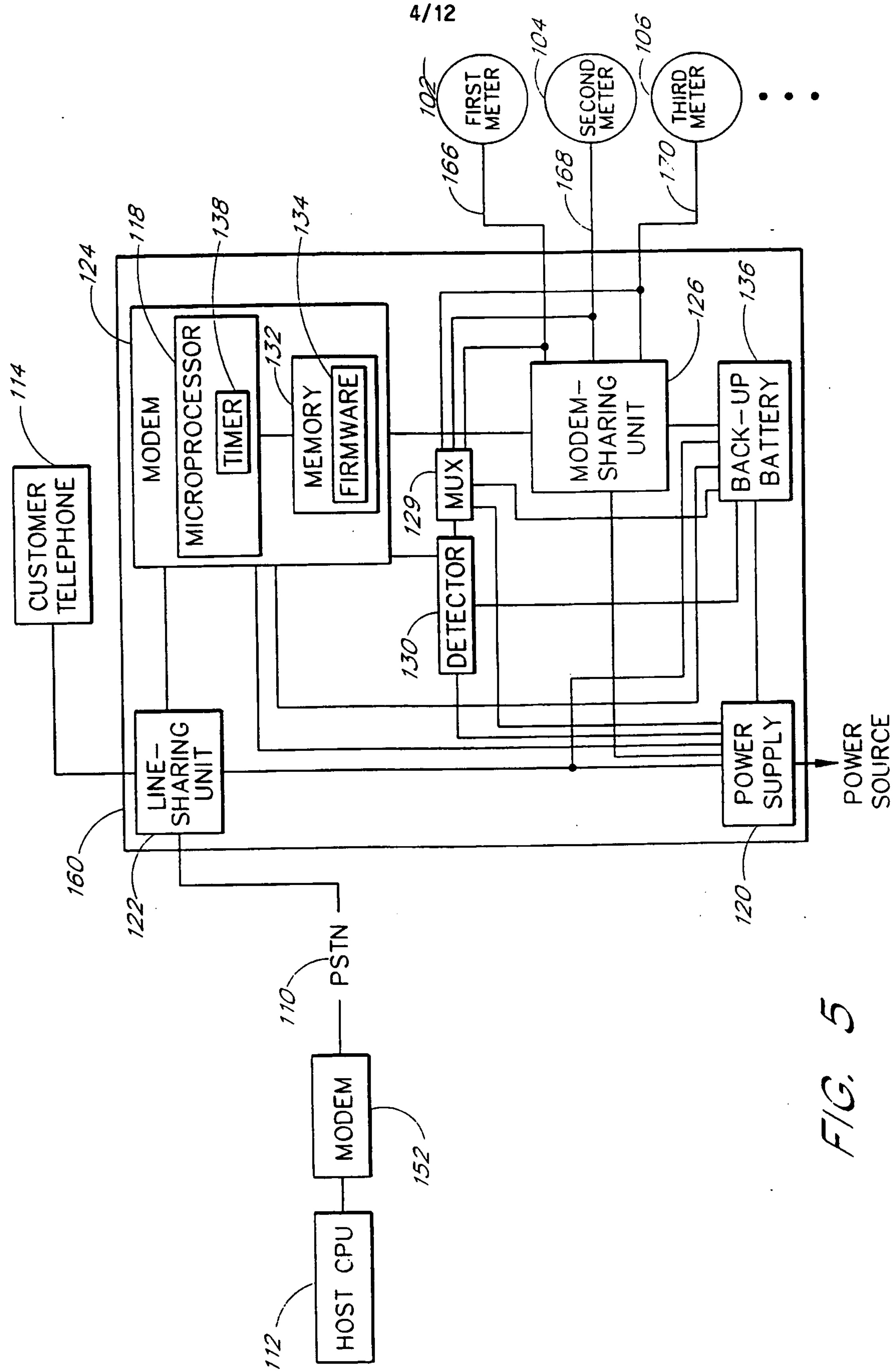

FIRST METER
SECOND METER
THIRD METER
102
104
106
166
168
170
124
118
138
134
132
126
136
114
CUSTOMER TELEPHONE
MODEM
MICROPROCESSOR
TIMER
MEMORY
FIRMWARE
MODEM-SHARING UNIT
BACK-UP BATTERY
MUX
129
DETECTOR
130
LINE-SHARING UNIT
POWER SUPPLY
POWER SOURCE
160
122
120
PSTN
110
MODEM
152
HOST CPU
112

FIG. 5

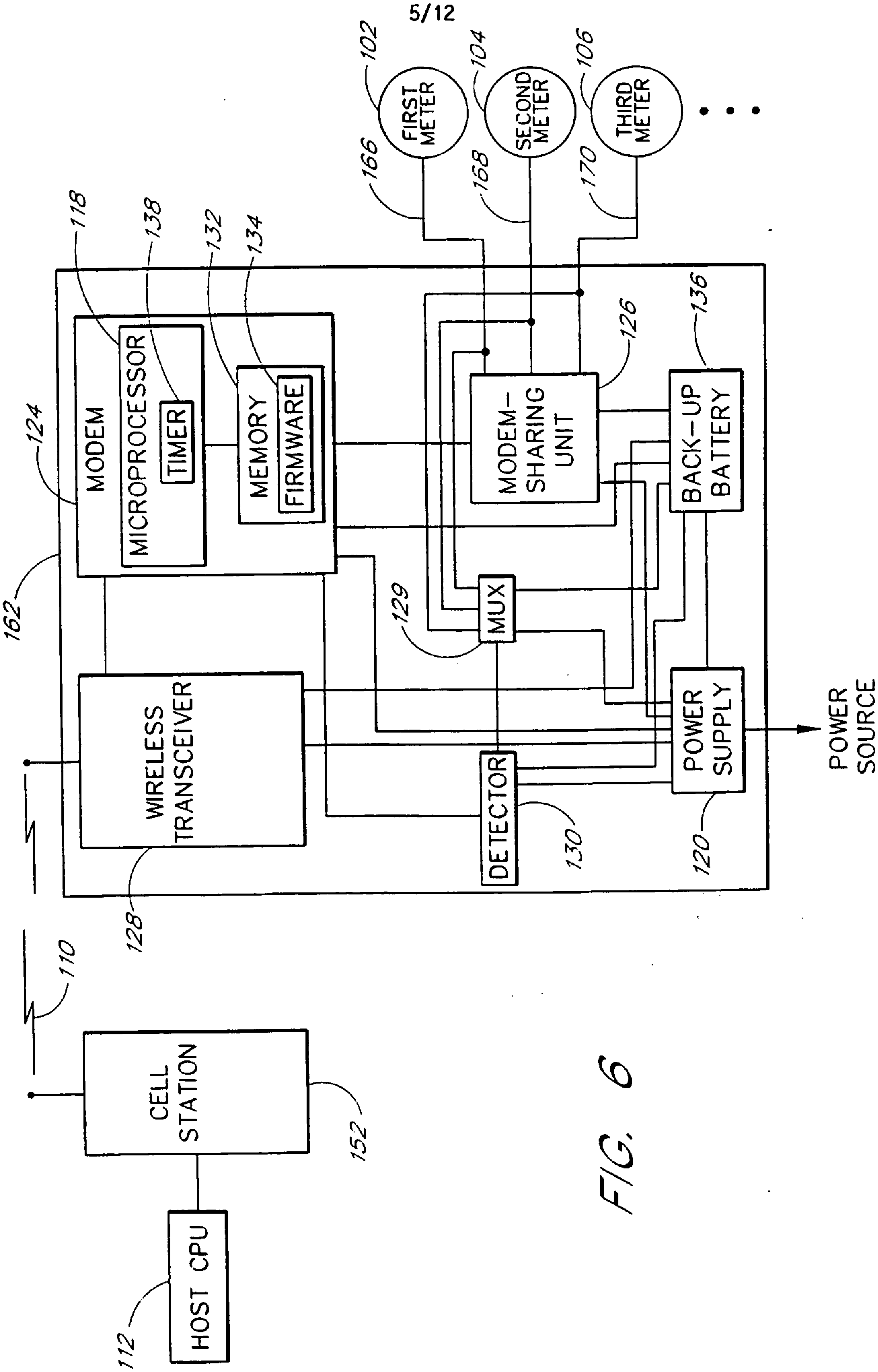
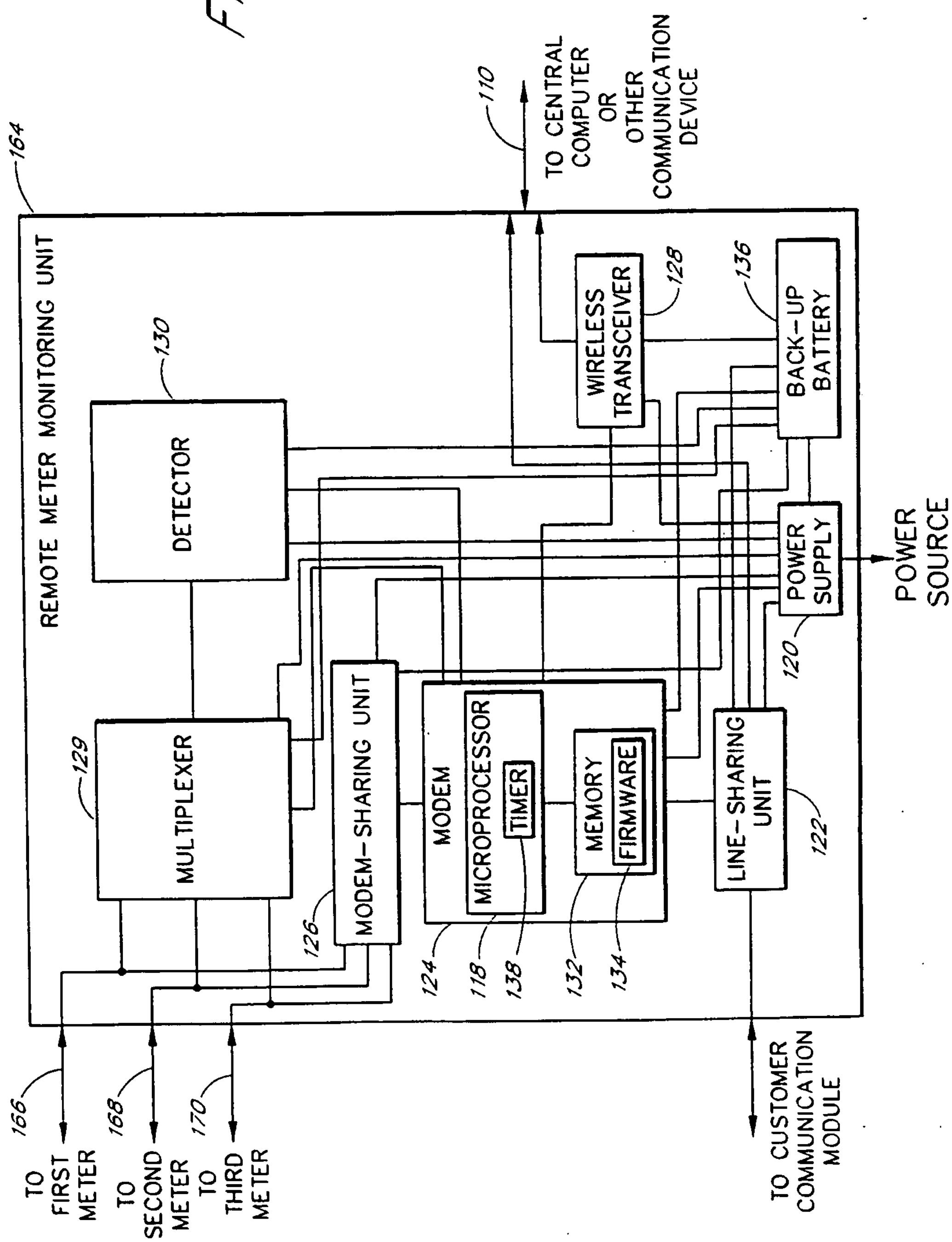

FIRST METER
SECOND METER
THIRD METER
102
104
106
166
168
170
118
138
132
134
124
126
136
162
129
MODEM
MICROPROCESSOR
TIMER
MEMORY
FIRMWARE
MODEM-SHARING UNIT
BACK-UP BATTERY
MUX
WIRELESS TRANSCEIVER
DETECTOR
POWER SUPPLY
POWER SOURCE
128
130
120
110
CELL STATION
152
HOST CPU
112

FIG. 6

FIG. 7


REMOTE METER MONITORING UNIT
164
DETECTOR
130
MULTIPLEXER
129
MODEM-SHARING UNIT
126
MODEM
MICROPROCESSOR
TIMER
MEMORY
FIRMWARE
124
118
138
132
134
WIRELESS TRANSCEIVER
128
BACK-UP BATTERY
136
POWER SUPPLY
120
POWER SOURCE
LINE-SHARING UNIT
122
110
TO CENTRAL COMPUTER OR OTHER COMMUNICATION DEVICE
166
TO FIRST METER
168
TO SECOND METER
170
TO THIRD METER
TO CUSTOMER COMMUNICATION MODULE

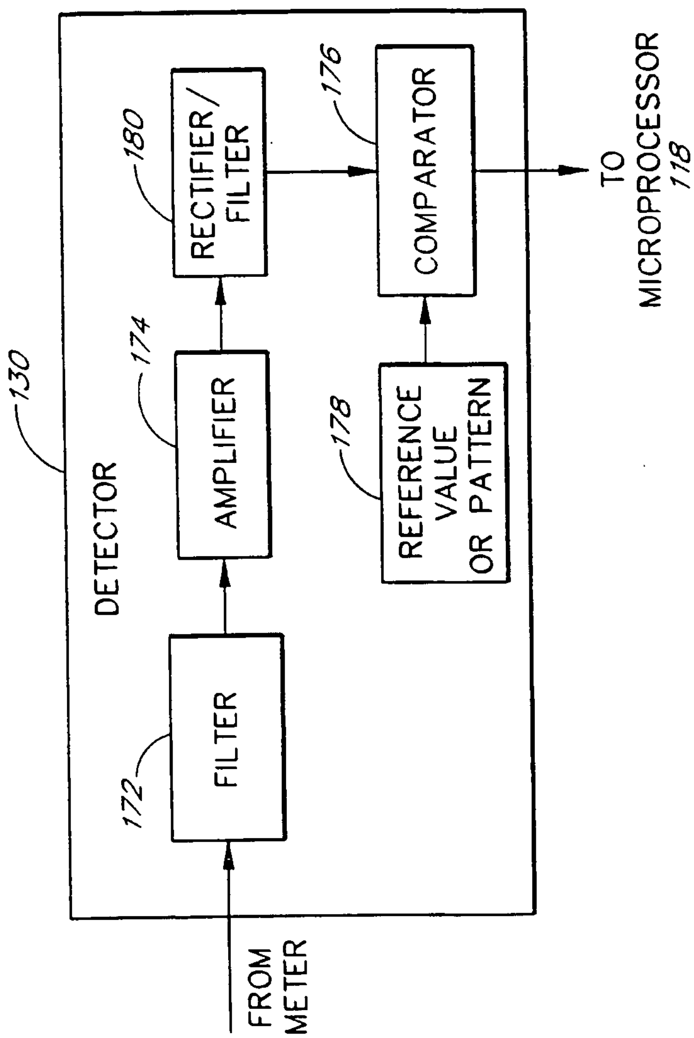

DETECTOR
130
FILTER
172
AMPLIFIER
174
RECTIFIER/ FILTER
180
COMPARATOR
176
REFERENCE VALUE OR PATTERN
178
FROM METER
TO MICROPROCESSOR 118

FIG. 8

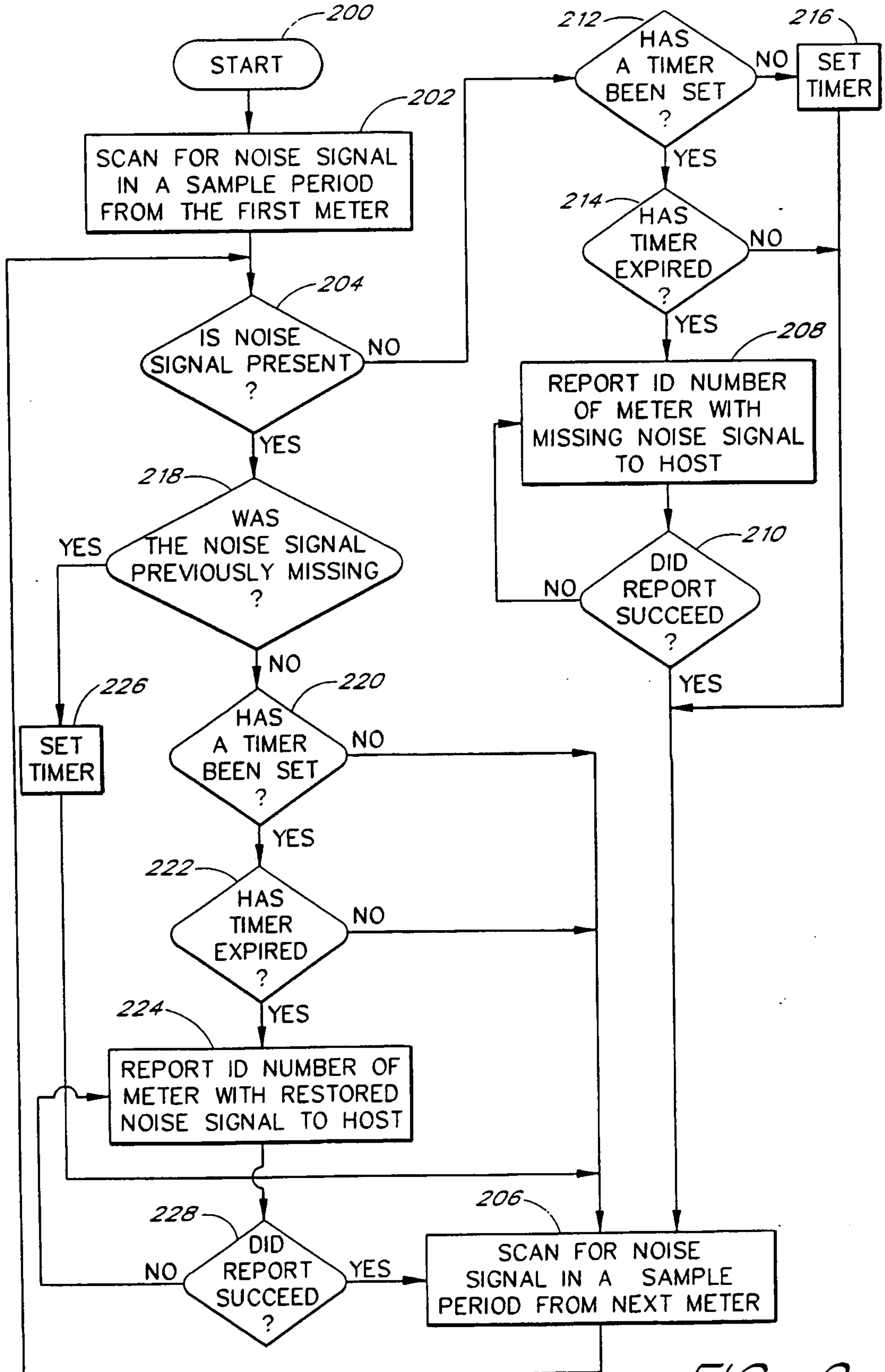

200
START
202
SCAN FOR NOISE SIGNAL IN A SAMPLE PERIOD FROM THE FIRST METER
204
IS NOISE SIGNAL PRESENT ?
NO
YES
212
HAS A TIMER BEEN SET ?
NO
216
SET TIMER
YES
214
HAS TIMER EXPIRED ?
NO
YES
208
REPORT ID NUMBER OF METER WITH MISSING NOISE SIGNAL TO HOST
210
DID REPORT SUCCEED ?
NO
YES
218
WAS THE NOISE SIGNAL PREVIOUSLY MISSING ?
YES
NO
226
SET TIMER
220
HAS A TIMER BEEN SET ?
NO
YES
222
HAS TIMER EXPIRED ?
NO
YES
224
REPORT ID NUMBER OF METER WITH RESTORED NOISE SIGNAL TO HOST
228
DID REPORT SUCCEED ?
NO
YES
206
SCAN FOR NOISE SIGNAL IN A SAMPLE PERIOD FROM NEXT METER

FIG. 9

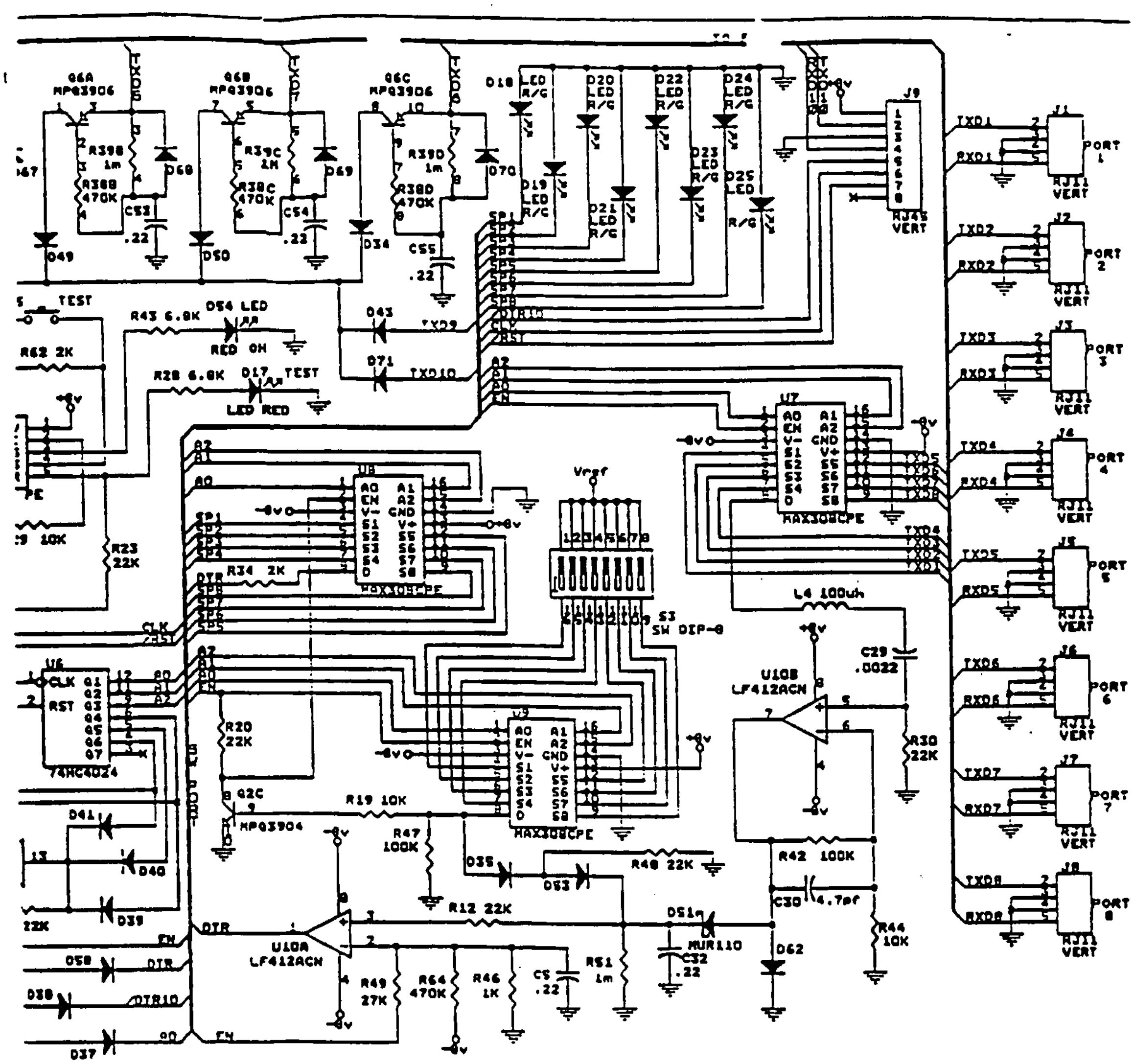


FIGURE 10
PART A

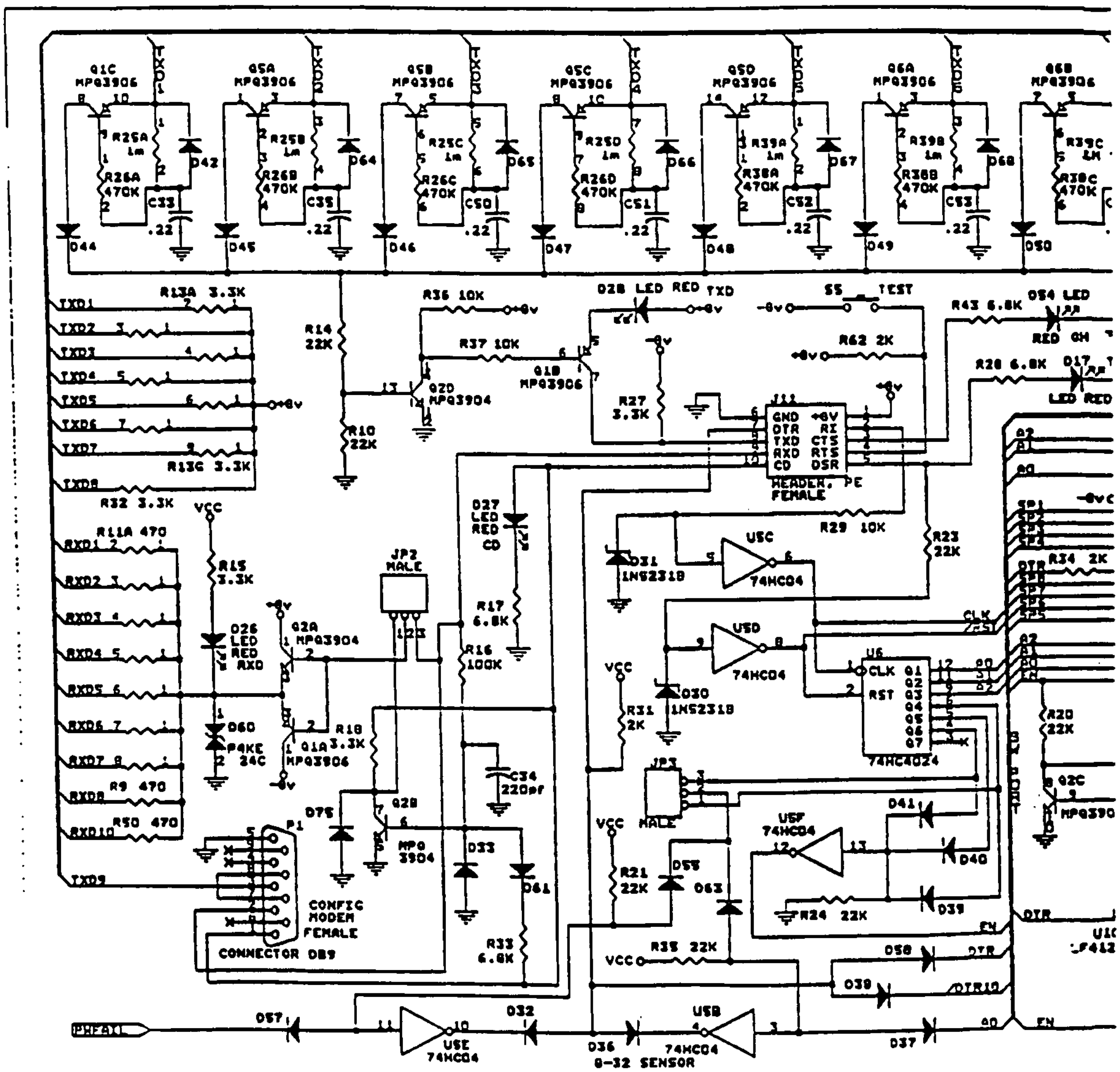


FIGURE 10
PART B

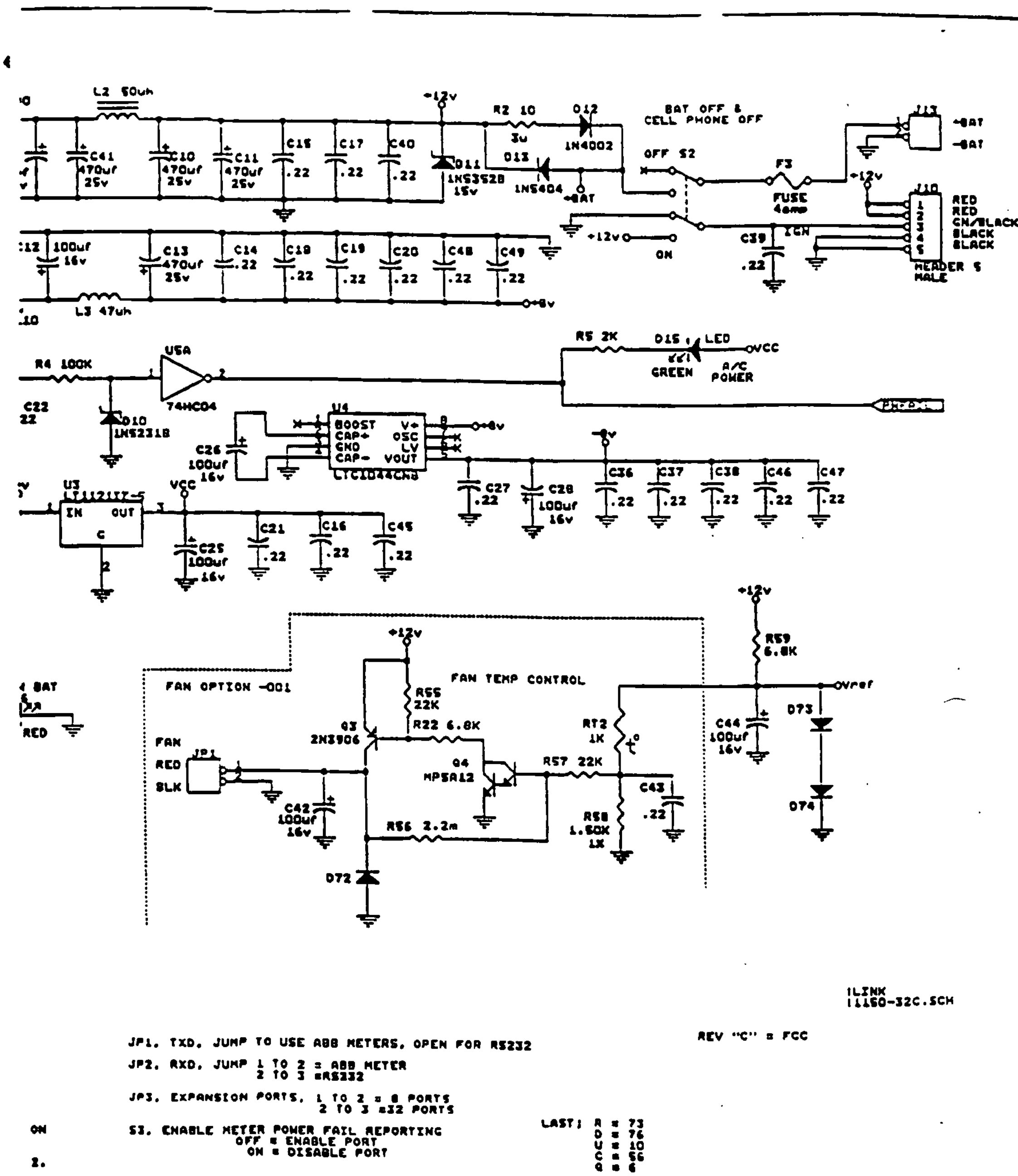
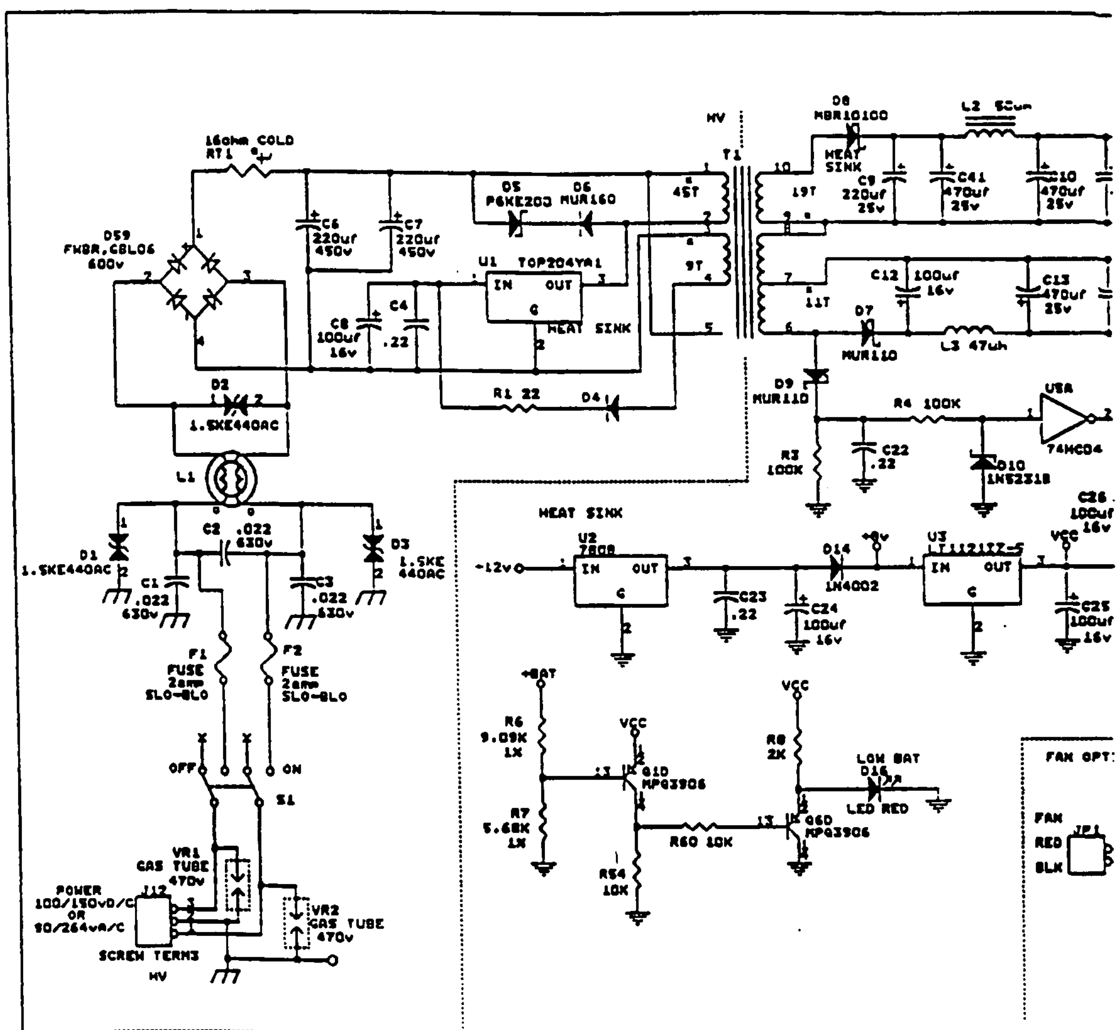


FIGURE 11
PART A



POWER SUPPLY;

32 watts OUTPUT
44 watts MAX INPUT
STANDBY POWER, 3watts
INPUT, 90-150v A/C-O/C

OUTPUTS: 13.6v ←7%, 100ma TO 2.2amp
8v ←5%, 220ma
-8v ←5%, 40ma

FAN "ON" LOW = 136f
FAN "ON" HIGH = 155f

NOTE:

ALL UNMARKED RESISTORS ARE 1/4w,5%

ALL UNMARKED DIODES ARE 1N4148 TYPE, BAS16L

MAX INPUT POWER = 38w max
EFF = 75%

LOW BATTERY DET (D16)
THRESH = 11.5v

POWER SUPPLY COVER MUST HAVE ELECT CONNECTION
CONNECTION TO EARTH GND (J12-2).

HEAT SINK MUST HAVE ELECT CONNECTION TO U1-2.

FIGURE 11
PART B

JP1, TXD, JL

JP2, RXD, JL

JP3, EXPANSI

S3, ENABLE F

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/16871

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :Please See Extra Sheet.
US CL : 340/870.02, 870.03, 870.09, 870.16; 324/201; 310/27; 375/260
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 340/870.02, 870.03, 870.09, 870.16; 324/

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST
search terms: detect, detector, utility, meter, EMF, noise

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,748,104 A (ARGYROUDIS et al) 05 MAY 1998	1-42
A	US 5,717,718 A (ROWSELL et al) 10 FEBRUARY 1998	1-42
A	US 5,541,589 A (DELANEY) 30 JULY 1996	1-42
A	US 5,473,322 A (CARNEY) 05 DECEMBER 1995	1-42
A	US 4,707,679 A (KENNON et al) 17 NOVEMBER 1987	1-42
A	US 4,697,182 A (SWANSON) 29 SEPTEMBER 1987	1-42
A	US 4,760,395 A (MACALINDIN) 26 JULY 1988	1-42
A	US 5,311,125 A (KRAUSE et al) 10 MAY 1994	1-42

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
14 SEPTEMBER 2000	12 OCT 2000

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	ALBERT WONG James R. Matthews
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/16871

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (7):

G08B 23/00, 19/00, 21/00; G08C 15/06; H02K 33/00; G01N 27/76; H04K 01/10